Multi-Aspect Assessment of 2025 Post Fire for California State Park – Hungry Valley SVRA

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Chapter 1: Introduction

Written Draft — Levi Freed & Emily Sorensen
Edits & Revisions — Ethan Marquez

The landscape of fire is rapidly changing due to the effects of climate change, introduction of invasive species, clearing of fire resistant vegetation for agricultural purposes, and the spread of urban areas into incredibly fire-prone areas. Monitoring this landscape for potential fire hazards as well as mapping fire destruction and potential regeneration has created a need for precise, high-resolution images of the landscapes. Sources for remotely sensed imagery include several satellite based platforms like LandSat and MODIS datasets, but these datasets come with potential issues. Traditionally-acquired satellite imagery based datasets may have issues regarding spatial resolution, availability based on time, and potential expense.

One alternative that solves several of these issues is the utilization and incorporation of drone data. Drone imagery is an excellent tool in field surveying due to its high spatial resolution, usually ranging between two to five centimeters. This forms a stark contrast when compared to publicly available satellite imagery ranging between one to ten meters for spatial resolution. Furthermore, data can be collected immediately after a fire catastrophe without having to wait for a satellite to pass over the affected area. This can be exacerbated even further should the coverage area of the fire extend beyond the coverage of a satellite image swath, requiring a revisit of the satellite to fully cover the area. Additionally, with the correct training and permitting, drone data may be acquired during the fire catastrophe to better understand the nature of fire behavior. Drone data does present a challenge in initial

investment of the drone and appropriate sensors, but this investment is generally shouldered by researchers and academic institutions that allow the use of this equipment for public research purposes.

As will be outlined further in this introduction, there are substantial grounds warranting the application of drone based surveying in Hungry Valley SVRA after the 2024 Post Fire. The primary goal of this research project is to gain a better understanding of the effect of the Post Fire on the landscape as well as begin to analyze the recovery of the landscape. Several techniques were used to analyze the landscape holistically. Using drone imagery and NDVI analysis, vegetation regrowth was surveyed after the fire. This report intends to determine the spatial correlation of vegetation regrowth with burn severity using drone-based mapping and imagery analysis, ground surveying of trees, and vegetation box plots.

This research project was conducted on March 8th, 2025. The team consisted of six people split into three groups for field analysis, and then worked as a single unit for the drone flight. The weather conditions were fair and mostly sunny, with a slight breeze present, and the recorded temperature was 64° Celsius. As such, conditions were ideal for drone flight and imagery capture. The overall research project had the following field objectives:

1. Conduct field box-plot (Relevé) surveys of vegetation within the area of drone flight.
2. Perform a tree health survey of Oak trees within drone flight area.
3. Perform a drone flight in which RGB and NIR data would be collected.

Chapter 2: Scientific Background

Written Draft — Levi Freed, Emily Sorensen, Ethan Marquez, Arman , Jaime Beltran
Edits & Revisions — Ethan Marquez

Section 1: Wildfires & Their Environmental Impact

Written Draft — Emily Sorensen
Edits & Revisions — Ethan Marquez

Wildfires play a critical role in shaping landscapes, particularly through their interaction with geomorphic processes like erosion and sediment movement. Understanding this is essential for preparing for secondary hazards, such as landslides, that often follow in a wildfire's wake. As a State Vehicle Recreation Area, it is important for Hungry Valley to understand the geomorphic consequences of fire, such as erosion and increased landslide potential so that remediation efforts can be implemented and a safe environment can be made available to the public once again. Fire is a powerful and transformative force that can have significant effects on the materials that it comes into contact with. It has the ability to change the physical and chemical properties of these materials. In Introduction to Fire in California, Carle (2021) discusses properties influenced by fire, including hydrophobicity, nutrient cycling, and erosion potential. Fire can cause plant waxes to seep into the soil, making it hydrophobic, which means the soil repels water instead of absorbing it. This disrupts nutrient cycling by vaporizing nutrients, killing microorganisms, and burning up organic matter. As a result, the land experiences increased erosion, since water runs off more easily, and vegetation that stabilizes soil is lost.

The aftermath of wildfires affect how and where vegetation recovers, and within this project's study area, the 2024 Post Fire significantly altered the landscape.

Section 2: The 2024 Post Fire & Aftermath (CA & Hungry Valley SVRA)

Written Draft — Emily Sorensen
Edits & Revisions — Ethan Marquez

The 2024 Post Fire was active for 11 days, and originated near North Peace Valley Road, south of Interstate 5 in Gorman, CA. It rapidly spread south through the Hungry Valley State Vehicular Recreation Area (SVRA), extending into the Los Padres National Forest and Angeles National Forest, and moving toward Pyramid Lake in the eastern Topatopa Mountains and southern Sierra Pelona Mountains of the Transverse Ranges. The chaparral plants that dominate Hungry Valley's vegetation are resinous with thick waxy coatings, which are highly flammable. These compounds, when burned, volatilize and seep into the soil, creating a hydrophobic barrier that prevents water from being absorbed. After a wildfire, this condition is exacerbated if it rains, as the water can't penetrate the soil, leading to increased runoff and the potential for mudslides. The burned landscape included a variety of fuel types such as annual grasses, mature chaparral, scrub oak, oak trees, desert scrub, scattered pine, and riparian vegetation. According to an incident summary report published by CAL FIRE, the region experienced an above-average grass crop due to two consecutive years of high rainfall, with precipitation reaching 130–150% of normal levels during the 2023 water year. This abundance of fine fuels significantly contributed to the fire's intensity and spread, further warranting the urgency and need for analytical approaches to properly assess vegetation health conditions after the fire.

Section 3: NDVI Analysis Component

Written Draft — Ethan Marquez
Edits & Revisions — Ethan Marquez

One of the traditional methods for analyzing vegetation health is the utilization of a Normalized Difference Vegetation Index. Gillespie et al. (2018) described the range of values for NDVI as a scale between the values of +1 and -1, with positive values greater than 0.5 representing greener healthier vegetation, and negative values less than zero representing little to no vegetation, which can indicate poor vegetation health, dying plant life, diseased or dead vegetation, or at times non-plant objects such as soil, waterbodies, or other elements of the terrain and environment. Furthermore, they suggest that NDVI serves as an indicator of plant biomass, photosynthetic activity, and biodiversity. According to Ba et al. (2022), a gradual increase in the number of wildfires over the last several decades, as well as fires direct devastation on vegetation growth and succession cycles, has prompted the scientific community to further investigate the resulting reactions of vegetation to wildfires and burn damage, with NDVI serving as an integral component in analyzing pre-fire and post-fire vegetation health conditions. Granted, NDVI as a vegetation index can be utilized within many different research concepts and topics outside of fire and burn assessments. For example, in a research study by Dong et al. (2019), decreases and increases in NDVI values for vegetation provided visible, quantifiable evidence of plant sensitivity to droughts in Northern and Southern California. Another example includes a study by Sun et al. (2017) on two Pinot Noir vineyards in California that utilized NDVI values calculated using Landsat satellite imagery data

obtained from 2013 to 2014 in grape yield predictions. Ultimately, NDVI is just one integral analysis method and indicator of vegetation health following the destruction left in the wake of wildfires, and it is important to consider multiple methods of vegetation health assessment in order to garner a proper, fuller understanding of the interactions between fire and its effects on vegetation regrowth and resilience.

Section 4: Tree Analysis Component

Written Draft — Jaime Beltran
Edits & Revisions — Ethan Marquez

Post-wildfire tree assessments provide critical insight into ecosystem resilience, tree mortality, and future forest structure. A foundational model for estimating post-fire tree mortality was developed by Hood et al.(2017), who used data from twelve western U.S. conifers to demonstrate that crown scorch percentage and tree diameter are strong predictors of delayed tree death. Their research underscores the importance of collecting precise metrics such as char height and crown damage in guiding post-fire management decisions. Building on this, Arkin et al.(2023) proposed a novel method for estimating individual tree scorch height and volume using drone imagery and photogrammetry, offering a valuable alternative when direct field measurements—such as diameter at breast height—are not feasible, as was the case in this study. This technique not only improves data accuracy but also enhances safety and efficiency in post-fire fieldwork. Finally, research by Hultine et al.(2020) on Populus fremontii highlights the species' adaptive capacity to extreme environmental conditions. While the tree displays notable resilience to fire and

drought, its long-term survival is increasingly threatened by intensifying climate stressors. Collectively, these studies show the importance of integrating physiological insight with innovative measurement approaches to assess fire impacts on species like Populus fremontii in a fire-prone ecosystem.

Section 5: Vegetation Analysis Component

Written Draft — Levi Freed
Edits & Revisions — Ethan Marquez

The relevé method has been used for decades as a reliable way to document vegetation communities, which is especially useful when trying to understand how landscapes recover after disturbances like wildfire. The method focuses on identifying plant species, estimating their cover, and recording vegetation structure within set plots. Because it emphasizes placing plots in representative, undisturbed sections of vegetation, it's a good fit for capturing the early stages of regrowth in post-fire environments. This kind of data is crucial when trying to track patterns of recolonization, identify which species are coming back first, and understand how different vegetation layers respond over time (Poore, 1955; Mueller-Dombois & Ellenberg, 1974; Barbour et al., 1999).

Newer large-scale vegetation monitoring techniques are starting to combine traditional field surveys with tech-driven approaches like remote sensing and drone imagery, which is especially helpful in fire-scarred or hard-to-access areas. For example, Sparrow et al. (2020) describe a method for monitoring rangeland ecosystems that uses permanent plots, GPS, and digital tools to collect consistent

vegetation and soil data. This kind of modular setup allows for repeat surveys over time and can be paired with drone-based mapping, making it highly relevant for post-fire monitoring. When these types of methods are combined—plot-based vegetation surveys like relevés, high-resolution drone imagery, and targeted soil sampling—they create a more complete picture of fire impact and landscape recovery. As such, this research project sought to utilize drone and ground-based methods in conjunction to map out early regrowth and better understand how different parts of the burned landscape are gradually recovering.

Section 6: Drone Applications

Written Draft — Arman Khachikyan
Edits & Revisions — Ethan Marquez

The DJI Mavic 3 Enterprise (M3E) is a compact and high-precision drone designed for professional mapping and surveying applications. It features a 4/3 CMOS 20MP wide camera with a mechanical shutter, allowing for accurate data capture with minimal distortion—ideal for creating orthomosaics. Its Real-Time Kinematic (RTK) module enhances positioning accuracy, which is essential for generating the high-resolution and spatially accurate orthomosaics. In recent studies and practical applications, the M3E has proven effective in generating high-resolution orthomosaics for vegetation analysis and land monitoring. (Tan et al., 2024). When joined with GIS software, the RGB imagery captured by the M3E can be processed to compute indices such as the Normalized Difference Vegetation Index (NDVI). Although the drone itself does not have a dedicated multispectral sensor, NDVI can

still be estimated using compatible third-party sensors or by integrating near-infrared imagery from additional payloads. Overall, the M3E offers an efficient and cost-effective platform for collecting aerial imagery that can be processed into orthomosaics and analyzed using NDVI and RGB in GIS software. The integration of M3E data into GIS workflows enables detailed spatial analysis, such as mapping crop stress, assessing vegetation health, or monitoring landscape changes. (Agüera Vega et al., 2014). The use of both NDVI and RGB layers enhances interpretability and allows for more robust decision-making in agricultural and environmental projects. NDVI can also be used to assess the moisture content of vegetation, as drier vegetation tends to have lower NDVI values. For this research project, the analysis of the burn scar helps produce a better understanding of the status of vegetation in the Hungry Valley SVRA following the 2024 Post Fire. By comparing pre-fire and post-fire NDVI values, it becomes possible to assess the burn severity of the fire, visualize the areas most affected as well as unaffected by this disaster, and finally, to identify areas with significant levels of vegetation loss as well as vegetation regrowth.

Chapter 3: Project Study Area

Written Draft — Jaime Beltran
Edits & Revisions — Ethan Marquez

The primary geographic focus for this research will be Southern California, a region that regularly experiences significant wildland fires. Specifically, this research project will focus on the Hungry Valley region, which experiences frequent wildfires due to a combination of dry weather, Santa Ana winds, and high fuel loads. Hungry

Valley features chaparral and shrubland ecosystems, which are particularly fire-prone due to their dry conditions and dense vegetation. Data pertaining to recent fire events in this area was collected on March 8th, 2025, when the team was granted access to the burned regions of the Hungry Valley State Vehicle Recreation Area (SVRA), where the wildfire that occurred in June 2024. The areas of the park are closed to the public to support the natural regeneration of the ecosystem.

Figure 1: Overhead view of study area in Hungry Valley SVRA from Soil Website.

Chapter 4: Methodology

Written Draft — Nochtli Gomez
Edits & Revisions — Ethan Marquez

Section 1: Data Preparation

The drone-based imagery was collected using a DJI Mavic 3M Multispectral UAV, equipped with Red, Green, RedEdge, and Near Infrared (NIR) sensors. A total of 1,365 images were captured over the study site, comprising 273 images per band (Red,

Green, RedEdge, and NIR) as well as a composite image set. These single-band images were subsequently stitched together using ArcGIS Pro to create orthomosaic rasters for each spectral band. These orthomosaics were then used in NDVI (Normalized Difference Vegetation Index) calculations to evaluate post-fire vegetation regrowth. The resulting NDVI products were compared with 2022 aerial imagery.

Section 2: Image Sorting

Prior to orthomosaic processing, the raw drone imagery was sorted by spectral band using a Python script executed in Jupyter Notebook. The script used the *os* and *shutil* modules to programmatically organize the 1,092 individual images into separate folders for Red, Green, RedEdge, and NIR bands. Below is the python script that sorted all the 1,092 R, G, RE, and NIR images into four different folders:

```
import os
import shutil

#Set your image directory
image_dir = "C:/Spring_2025/404/HungryValley/DJI_202503081259_033_ChickenNugget/"

# Define band labels and corresponding folder names
bands = {
    '_MS_R': 'Red',
    '_MS_G': 'Green',
    '_MS_NIR': 'NIR',
    '_MS_RE': 'RedEdge'
}

# Loop through files and sort them
for filename in os.listdir(image_dir):
    # Only move image files
    if filename.lower().endswith((".tif", ".jpg", ".jpeg", ".png")):
        for key, folder in bands.items():
            if key in filename:
                src_path = os.path.join(image_dir, filename)
```

```
                dest_folder = os.path.join(image_dir, folder)
                os.makedirs(dest_folder, exist_ok=True)
                dest_path = os.path.join(dest_folder, filename)

                shutil.move(src_path, dest_path)
                print(f"Moved {filename} to {folder}")
                break  # Stop after finding the first match

print("Images sorted by band!")
```

This automated sorting ensured compatibility with the orthomosaic generation process in ArcGIS Pro. Although the DJI Mavic 3M images were imported into the Orthomosaic Wizard, the software did not automatically assign bands for processing. Manual sorting through Jupyter Notebook was necessary to prepare band-specific orthomosaics, particularly for Red, Green, and NIR images used in NDVI analysis.

Section 3: Orthomosaic Generation

To generate georeferenced orthomosaics from DJI Mavic 3M multispectral imagery, the Orthomosaic Wizard in ArcGIS Pro 3.3 was used. This tool processed images for the Red and NIR bands separately. The procedure included band alignment, mosaicking, orthorectification, and radiometric corrections. The following steps outline the orthomosaic workflow:

1. **Project Setup**

   Separate ortho mapping workspaces were created for the Green, Red, and NIR bands. The sensor model was automatically recognized as “DJI Mavic 3 Multispectral.” Images were organized into folders per band, and the metadata defined the geolocation and orientation.

2. **Image Collection Configuration**

   Geolocation information was loaded from EXIF metadata, and the workspace coordinate system was set to **WGS 1984 UTM Zone 11N** with vertical coordinate system **EGM96 Geoid** (EPSG 32611). Average elevation values were extracted from the metadata to assist with alignment.

3. **Interior and Exterior Orientation**

   Block adjustment was performed to enhance the geometric accuracy of image frames. This included tie point generation, camera calibration (K1–K3 and P1–P2 parameters), and residual checks. "Use Orientations from Metadata" and "Compute Postinterior Standard Deviation" were selected for quality assurance.

4. **DSM and Orthorectification Settings**

   The *Digital Surface Model (DSM)* interpolation method was set to TIN Linear Interpolation with Gaussian 5×5 smoothing. The cell size was configured as 1×GSD (0.037 m). "Build Pyramids" and "Recalculate Statistics" were enabled, with the resampling method set to *Nearest Neighbor*.

5. **Color Balancing and Output**

   Global Fit color balancing was applied using a Second Order Color Surface. These settings carried over into the *Orthomosaic* output step. TIFF format was used for final output compatibility with Raster Calculator and NDVI analysis.

The output orthomosaics were saved as georeferenced TIFF files for each band. These served as the foundation for NDVI generation and comparison with NAIP imagery for post-fire vegetation analysis.

Section 4: NDVI and Vegetation Change Detection Workflow

NAIP Imagery Preprocessing

To compare vegetation conditions pre- and post-fire, 2022 NAIP imagery was downloaded in TIFF format. Bands 1 (Red) and 4 (NIR) were extracted using the *Make Raster Layer* tool. The imagery was reprojected to match the drone orthomosaic projection (**WGS 1984 UTM Zone 11N**) using the *Project Raster* tool. It was then clipped to the drone imagery's extent using *Extract by Mask* for alignment.The following is a python script to extract Red and NIR bands from 2022 NAIP imagery:

```
#Extract bands 1 and 4 from NAIP_project raster to align with drone extent

import arcpy
from arcpy.sa import *
from arcpy import env

#import naip raster to mask from
naip_raster =
r"C:\Spring_2025\404\HungryValley_Python\HungryValley_Python.gdb\HV_naip_2022_project
"

#Create temporary layers using bands 1 and 4
#arcpy.management.MakeRasterLayer(in_raster, out_rasterlayer, {where_clause},
{envelope}, {band_index})
red_Band = arcpy.MakeRasterLayer_management(naip_raster, "naip_red", "", "", "1")
nir_Band = arcpy.MakeRasterLayer_management(naip_raster, "naip_nir", "", "", "4")
print("Temporary layers created!")

#Set masked raster to be clipped
mask_Raster =
r"C:\Spring_2025\404\HungryValley_Python\SingleBands_HV_raster\Orthomosaic_Green.tif"

# Set output geodatabase
gdb_Path = r"C:\Spring_2025\404\HungryValley_Python\HV_FC_Processing.gdb"
```

```
#Clip bands to mask_Raster using the projection of mask_Raster
#ExtractByMask(in_raster, in_mask_data, {extraction_area}, {analysis_extent})
out_red_mask = ExtractByMask(red_Band, mask_Raster)
out_nir_mask = ExtractByMask(nir_Band, mask_Raster)

# Save to processing GDB
red_output = f"{gdb_Path}\\NAIP_Red_Clipped"
nir_output = f"{gdb_Path}\\NAIP_NIR_Clipped"

# Delete if already exists (safe save)
if arcpy.Exists(red_output):
    arcpy.Delete_management(red_output)
if arcpy.Exists(nir_output):
    arcpy.Delete_management(nir_output)

out_red_mask.save(red_output)
out_nir_mask.save(nir_output)

print("NAIP bands 1 and 4 clipped to drone imagery!")
```

NDVI Computation from UAV Orthomosaics

Multispectral orthomosaics derived from UAV imagery were used as input, specifically the Red and NIR band layers. Both bands layers were used to run the Raster Calculator by comparing the reflectance in the near-infrared (NIR) and red bands using the formula: **NDVI = (NIR - Red) / (NIR + Red)**. The NDVI calculations were used for both UAV and NAIP imagery, and outputs were saved in a geodatabase. The following python script shows the workflow processes for NDVI calculations:

```
#Run raster calculator using drone imagery red and nir bands
import arcpy
from arcpy.sa import *

#Set environment to Orthomosaic Red and NIR bands
arcpy.env.workspace = r"C:\Spring_2025\404\HungryValley_Python\SingleBands_HV_raster"
arcpy.CheckOutExtension("Spatial")
```

```
#Input rasters
drone_Red = Raster("Orthomosaic_Red.tif")
drone_NIR = Raster("Orthomosaic_NIR.tif")
print("Rasters sucessfuly imported!")

#Run NDVI calculations
drone_NDVI = (drone_NIR - drone_Red) /(drone_NIR + drone_Red)

#Output path (to your GDB)
drone_ndvi_output =
r"C:\Spring_2025\404\HungryValley_Python\HungryValley_Python.gdb\NDVI_2025"

#Safe save
if arcpy.Exists(drone_ndvi_output):
    arcpy.Delete_management(drone_ndvi_output)

drone_NDVI.save(drone_ndvi_output)
print("Drone NDVI layer saved successfully!")

#Check drone NDVI extent
print("NDVI min:", drone_NDVI.minimum)
print("NDVI max:", drone_NDVI.maximum)
print("NDVI mean:", drone_NDVI.mean)
```

Section 5: Tree Analysis

Written Draft — Jaime Beltran
Edits & Revisions — Ethan Marquez

Tree analysis following a wildfire is critical for understanding the immediate and long-term impacts of the event. It provides insight into tree mortality, structural integrity, species resilience, and helps guide post-fire management decisions. In this study area, eight trees were evaluated and 3 of these trees were located in the ravine area. For each tree, species, crown scorch percentage, and char height were recorded. Regrettably, there was no Dbh tape (Diameter at breast height) available to measure the height or the diameter of the tree. Pictures were taken and tree GPS coordinates were logged, and using these pictures, the char height of the tree can be estimated, as

well as the height of a section of a tree that has been scorched, burned, or reduced to charcoal. The trees in the study area are believed to be Fremont's Cottonwood (Populus Fremontii).

Within the confines of the study area, there were little to no dead trees, most of them having different ranges of burn severity. Some trees that were not logged but were nearby and looked very charred, but it could not be confirmed if they survived.

Tree #	Char height (Feet)	Description
1	Less than 1 ft.	Mostly healthy, base of the trunk is charred. Leaves look dry/dead. Thick trunk.
2	No burn	Seems untouched by fire, presence of moss growth. Leaves are dry/dead. Thick trunk.
3	4.5 feet	Badly burnt on one side, many branches on the floor. Tree is recovering. Dry leaves/dead. Thick trunk.
4	6 to 7 feet	Tree is burnt on all sides, bark is peeling from one side. Tree has leaves (noticeably dry). Thick trunk.
5	8 to 10 feet	Tree is burned on all sides, lots of bark burned off and scattered. Dry leaves/dead. Thick trunk.
6	9 to 10 feet	Tree was burned from all sides but is still holding onto the charred bark. Leaves are dry/dead. Slim trunk. Noticeable sap residue on tree.
7	20 to 25 feet	Tree with the highest char height, while badly burned, still seems alive. Leaves are dry/dead. Slim trunk.
8	6.5 to 7	Burned from all sides while still holding to its bark. Tree seems alive. Leaves are dry/dead. Slim trunk.

Section 6: Vegetation Box-Plots (Relevé Survey)

Written Draft — Levi Freed

Edits & Revisions — Ethan Marquez

Relevé plots surveys serve dual purposes. They provide validation of remotely sense images, both drone and satellite imagery. Plots representative of the survey site may be used for ground truthing the conclusions of a GIS or remote sensing based analysis. The secondary purpose of relevé plot surveys is to provide a more detailed understanding of the type and density of species present within the study area. GIS and remote sensing based analysis of vegetation often struggle in terms of clean identification of specific species and then further calculating the percentage of ground space taken up by vegetation. Relevés, while time consuming, can identify the presence of particular species, flowering cycles, invasive presence, health of plants, and the footprint covered by an individual species.

Relevé plots were selected to include the widest range of vegetative diversity displayed after the fire. A total of 5 plots were selected within the boundaries of the Study Area. Soil composition based on a basic visualization included native sandy soils mixed heavily with fine ash and other burned materials. This survey was conducted during early spring in which new vegetation was beginning to emerge. A bias may exist in this study due to a much lower than average rainfall which may be the primary reason for, or an impact upon the low amount of vegetation growth. Plots were 50 by 50 inch squares.

Plot #	Species List	Soil Condition	Veg % Coverage	Veg Health
1	9 Yerba Santas 3 Unknown/Damaged	Semi-Ashen, Sandy, Dehydrated	20% Vegetation and Veg Shadow, 20% Exposed Ashen Soil, 60% Exposed Sandy Soil	25% of species dead and gone to seed, species present small possibly new growth.
2	1 Yerba Santa w/ runner plant 3 Broom Sages 1 Unknown/Damaged	Heavy layer of ash and other burned materials over sandy dehydrated soil	40% Vegetation and Veg Shadow, 60% Ashen Soil	66% of species appear dying/dry and in distress. 33% Dead/Burned
3	1 Aster Family - Specie Unknown	Hard Packed Sandy Soil, Completely Dehydrated	5% Vegetation, 95% Packed Ash	100% New Growth.
4	10 Yerba Santa 1 Unknown/Mature Woody Plant	Primarily Sandy Soil. Moderate to Good Moisture.	85% Vegetation, 15% Sandy Soil	100% of species appear in good health. May have survived/been skipped over by fire based on size.
5	1 Yerba Santa 4 Grasses	Ashen and Native Soil, Some Moisture	15% Vegetation, 10% Ash, 75% Sandy Soil	100% of species appear to be new growth and of descent health

Figure 2: Measuring the Relevé box plots.

Figure 3: Measuring the Relevé Box Plots.

Chapter 5: Results

NDVI Analysis (UAV & NAIP Imagery)

The following pages contain the visual representations of the NDVI analyses for imagery obtained from the UAV drone flight on-site in 2025 as well as the NAIP imagery for 2022. Based on a cursory visual observation of the mapped NDVI values, it would appear that in the 2025 image, there are considerably minimal positive NDVI values indicating the presence of healthy green vegetation. The majority of the greenest vegetation observed in the study area appeared along the ravine portion of the Hungry Valley SVRA, where water was located at the base of the ravine. In stark contrast to this is the NDVI values derived from the NAIP imagery for 2022, which was used as a sample for pre-fire vegetation health conditions. After an initial visual observation of the NDVI values and distribution, they seem to mostly align with the distribution of the NDVI values in the UAV-based NDVI analysis, but with a significantly greater number of clusters and overall presence of healthy green vegetation compared to the post-fire NDVI analysis. However, it would appear that the NDVI analysis using the NAIP imagery would indicate a significantly greater volume of negative NDVI values, which may derive from the difference in spatial resolutions used for each analysis. Ultimately, setting aside the general massive quantity of negative or overall low NDVI values that cover most of the terrain, a careful observation of the strength of the NDVI values for healthy green vegetation along the ravine containing a stream indicates a decline in the overall healthy green vegetation in Hungry Valley from 2022 to 2025 following the aftermath of the 2024 Post Fire that ravaged the area.

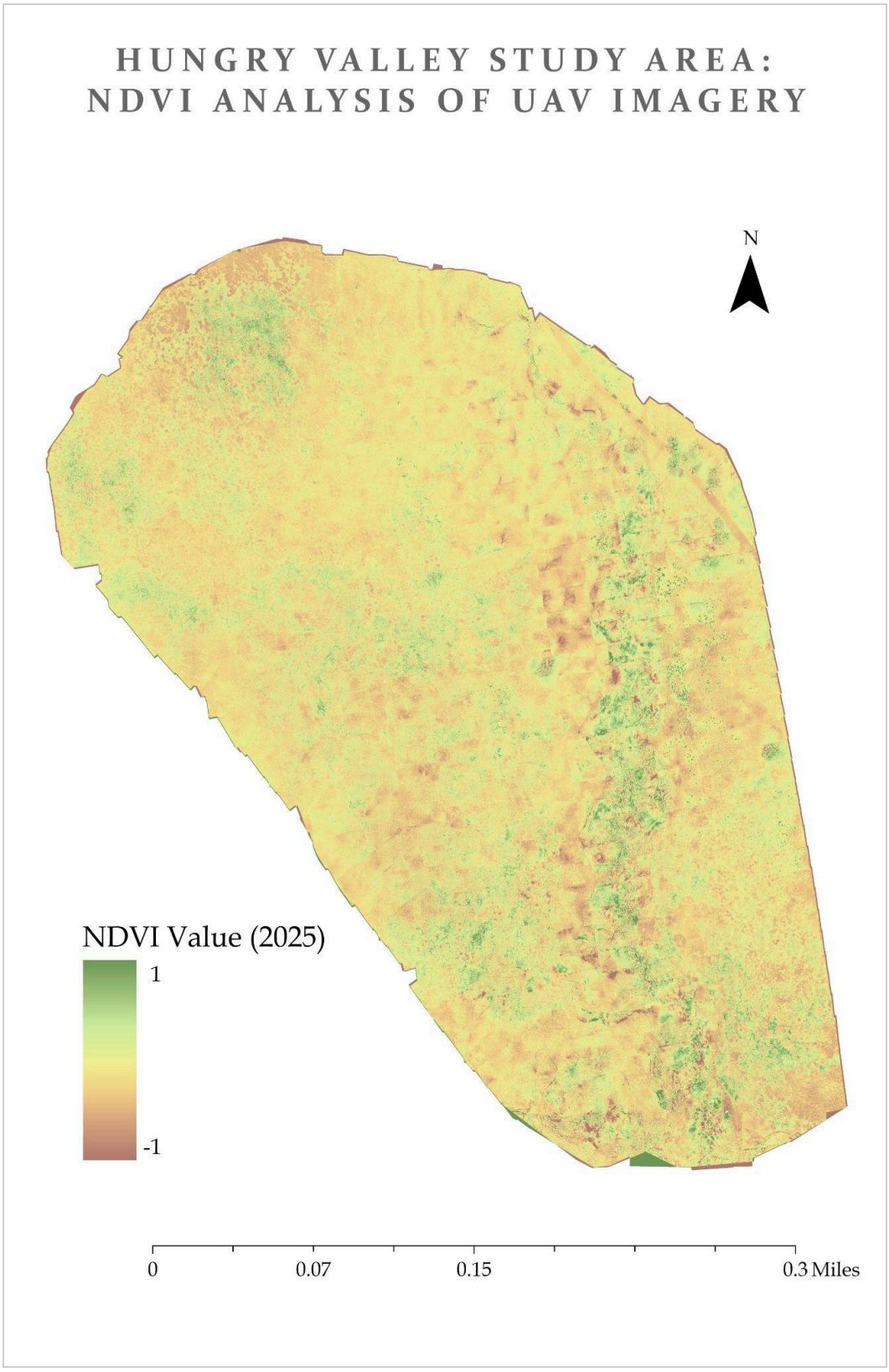

Figure 2: NDVI Analysis of study area within Hungry Valley using UAV imagery obtained in 2025.

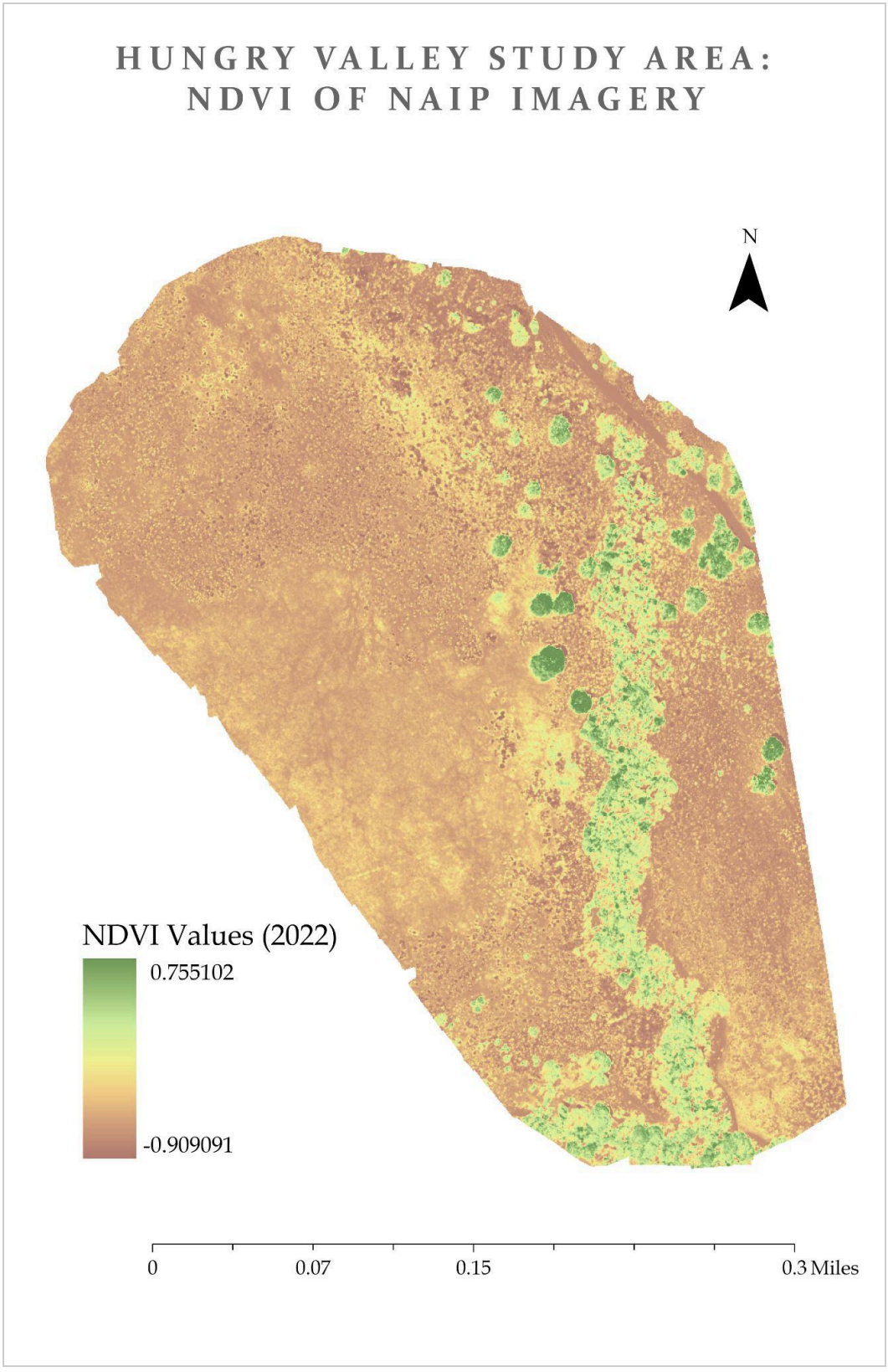

Figure 3: NDVI Analysis of study area within Hungry Valley using satellite imagery obtained in 2022.

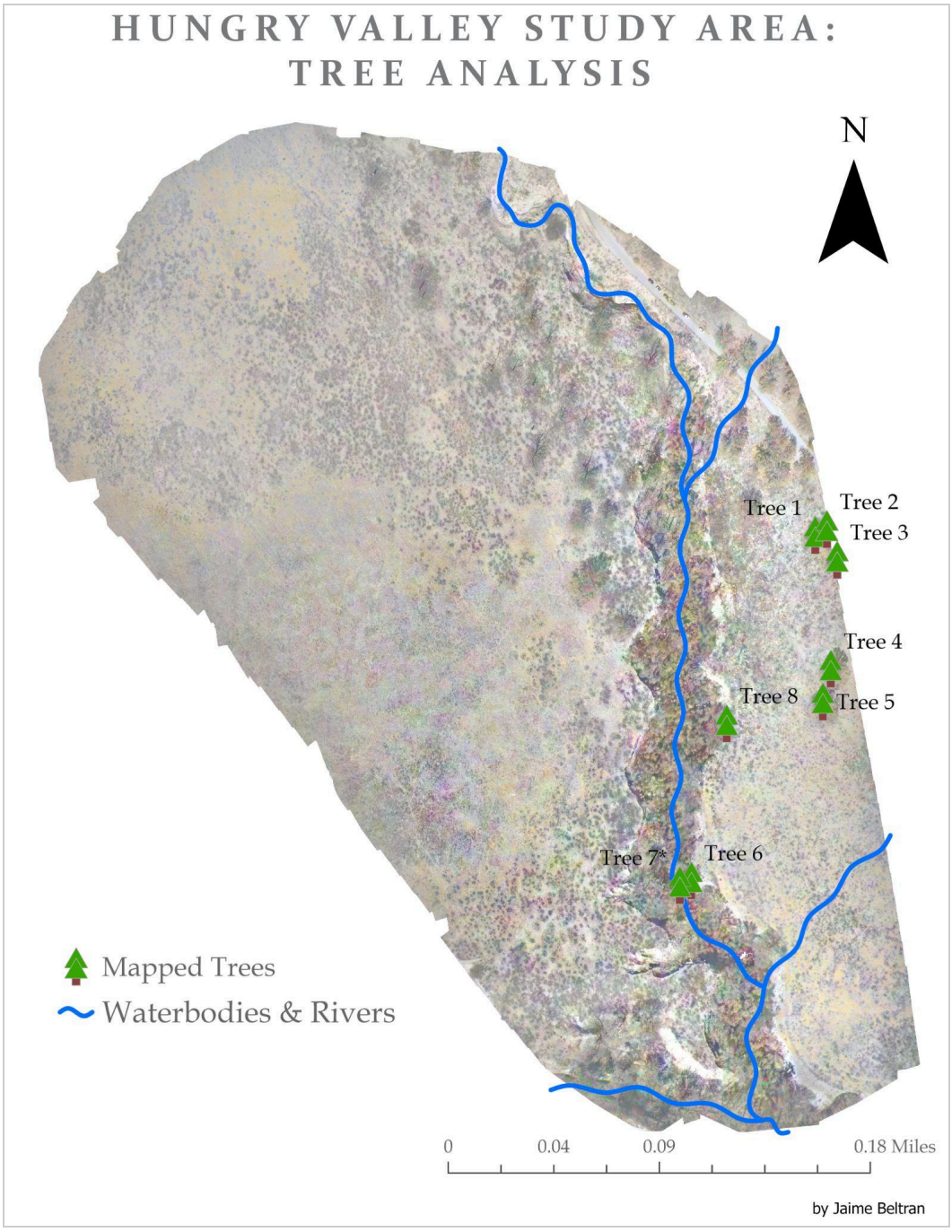

Figure 4: Composite imagery obtained from UAV drone flight overlaid with mapped trees used as ground control points, as well as rivers and water bodies within the observed study area.

Ground Truthing Vegetation

Analysis of NDVI indicated that approximately 7.26% of the study area was indicated to have healthy vegetation. NDVI pixels with values of 0.5 and higher were indicative of healthy green vegetation. Relevé surveys indicate a higher potential amount of regrowth. Average revegetation of each plot indicates 33% of each plot had been recolonized by native plants. This could be due to several factors:

1. Spatial resolution of drone imagery can not adequately capture each individual plant present on the ground.
2. Relevé plots are not indicative of true values of plant vegetation.
3. Sections of the study area that were completely covered in burned/bare ground areas were not identified as areas of interest for relevé survey.

Chapter 6: Discussion

This survey is only one snapshot of regrowth of the fire scar. Furthermore there were some limitations based on the amount of land we were able to survey. Due to drone battery life, the study area was limited to a small section of the burned area and may not be representative of the entire fire landscape. Furthermore this study is being conducted in the spring season where the landscape contains the highest amount of vegetation. This may present the area as having recovered further than is actually true and a more representative study may wish to take imagery from the middle of summer when the Post Fire occurred to better compare vegetation states.

Further research may be useful to understand the seasonality of fire landscapes and vegetation regrowth.

Chapter 7: Conclusion

The relevé data revealed that remotely sensed imagery alone does not capture the full scope of post-fire recovery. While NDVI analysis is useful for measuring general “greenness,” it doesn’t provide insight into species diversity or the ecological conditions those species are growing under. In our case, NDVI suggested that the study area was experiencing limited regrowth, indicating a more severe post-fire impact. However, field vegetation plots indicated that this was untrue. Several plant species are indeed returning to the burn area. Although many of these plants are small and slow to establish, their presence points to ongoing recovery that NDVI alone failed to detect. Of particular note are the species hardest to detect using drone data, small grassy annuals that may appear negligible due to the spatial resolution of the drone flight. The significant gap between NDVI results and on-the-ground relevé findings highlights the need for refining drone-based data collection methods to better represent vegetation health and species-level recovery in post-fire landscapes.

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